

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of aggregating a plurality of blocks related to a design configuration for extracting material from a particular location, the method including the steps of:
 - determining a selected volume of material to be extracted,
 - dividing at least a portion of the selected volume into blocks,
 - forming at least one cluster, and
 - propagating from at least one cluster, a cone.
2. A method as claimed in claim 1, further including the step of determining from intersections of the cones, a clump.
3. A method as claimed in claim 1 or 2, wherein the cone is propagated upwards using precedence arcs.
4. A method as claimed in claim 1, 2 or 3, wherein the cone is three dimensional.
5. A method as claimed in any one of claims 1 to 4, wherein the cone is minimal.
6. A method as claimed in any one of claims 1 to 5, wherein the cone includes a number of blocks.
7. A method as claimed in any one of claims 2 to 6, wherein the precedence arcs relate to an extraction order of corresponding clump(s) and / or block(s).
8. A method of determining slope constraints related to a design configuration for extracting material from a particular location, the method including the steps of:
 - using precedent arcs of blocks emanating from a selected clump to establish, at least in part, clump precedents.

9. A computer program product including:

a computer usable medium having computer readable program code and computer readable system code embodied on said medium for determining slope constraints related to a design configuration for extracting material from a particular location within a data processing system, said computer program product including:

computer readable code within said computer usable medium for performing the method as claimed in any one of claims 1 to 8.

10. Apparatus adapted to aggregating a plurality of blocks related to a design configuration for extracting material from a particular location, the apparatus including:

**first means for determining a selected volume of material to be extracted,
second means for dividing at least a portion of the selected volume into blocks,**

third means for forming at least one cluster, and

fourth means for propagating from at least one cluster, a cone.

11. Apparatus adapted to determining slope constraints related to a design configuration for extracting material from a particular location, the apparatus including:

first means for using precedent arcs of blocks emanating from a selected clump to establish, at least in part, clump precedents.

12. Apparatus adapted to aggregating a plurality of blocks related to a design configuration for extracting material from a particular location, the apparatus including:

processor means adapted to operate in accordance with a predetermined instruction set,

said apparatus, in conjunction with said instruction set, being adapted to perform the method as claimed in any one of claims 1 to 8.

13. Apparatus adapted to determining slope constraints related to a design configuration for extracting material from a particular location, the apparatus including:

processor means adapted to operate in accordance with a predetermined instruction set,

said apparatus, in conjunction with said instruction set, being adapted to perform the method as claimed in any one of claims 1 to 8.

14. A method of determining a cluster of material, the method including the steps of:

allocating at least a portion of the material between a plurality of blocks,
determining a first attribute related to co-ordinates corresponding to each block,

assigning the first attribute to each corresponding block,
determining a second and / or at least one further attribute(s) related to the plurality of blocks, and

aggregating at least two of the plurality of blocks in accordance with the first attribute and the second attribute.

15. A method as claimed in claim 14, wherein the second and / or further attribute(s) provide for distinction between material considered of value, and material considered to be of lesser or little value.

16. A method as claimed in claim 14 or 15, wherein the second and / or further attribute(s) corresponds to a positive value.

17. A method as claimed in claim 14 or 15, wherein the second and / or further attribute(s) corresponds to a spatial value.

18. A method as claimed in claim 14 or 15, wherein the second and / or further attribute(s) corresponds to grade of the material.

19. A method as claimed in any one of claims 14 to 18, wherein the at least two blocks are aggregated into a larger collection of blocks.

20. A method as claimed in any one of claims 14 to 19, further including repeating the steps defined to determination a further cluster from material already aggregated.

21. A method of removing material from a predetermined location, the method including the steps of:

determining a cluster in accordance with any one of claims 14 to 20, and scheduling the collections into one or more periods.

22. A computer program product including:

a computer usable medium having computer readable program code and computer readable system code embodied on said medium for determining slope constraints related to a design configuration for extracting material from a particular location within a data processing system, said computer program product including:

computer readable code within said computer usable medium for performing the method as claimed in any one of claims 14 to 21.

23. Apparatus adapted to determining a cluster of material, the apparatus including:

first means for allocating at least a portion of the material between a plurality of blocks,

second means for determining a first attribute related to co-ordinates corresponding to each block,

third means for assigning the first attribute to each corresponding block,

fourth means for determining a second and / or at least one further attribute(s) related to the plurality of blocks, and

fifth means for aggregating at least two of the plurality of blocks in accordance with the first attribute and the second attribute.

24. Apparatus adapted to determine the removal of material from a predetermined location, the apparatus including:

first means for determining a cluster in accordance with any one of claims 14 to 20, and

second means for scheduling the collections into one or more periods.

25. Apparatus adapted to determining a cluster of material, said apparatus including:

processor means adapted to operate in accordance with a predetermined instructions set,

said apparatus, in conjunction with said instruction set, being adapted to perform the method as claimed in any one of claims 14 to 20.

26. Apparatus adapted to determine the removal of material from a predetermined location, said apparatus including:

processor means adapted to operate in accordance with a predetermined instructions set,

said apparatus, in conjunction with said instruction set, being adapted to perform the method as claimed in any one of claims 14 to 20.

27. A method of determining characteristics of a selected portion of material, the method including the steps of:

determining the contents of the selected portion of material, and

identifying region(s) of material within the selected portion according to at least one of a plurality of characteristic(s).

28. A method as claimed in claim 27, wherein the determination of contents is performed from substantially the lowest level of the selected portion of material, and then upwards.

29. A method as claimed in claim 27 or 28, wherein the selected portion of material is a clump.

30. A method as claimed in claim 27, 28 or 29, wherein the characteristics are predetermined.

31. A method as claimed in any one of claims 27 to 30, wherein at least two of the characteristics reflect one or more grade(s) or value(s) of material.

32. A method as claimed in claim 31, wherein the region(s) distinguish between ore considered of value, waste material and / or impurity.

33. A method as claimed in claim 32, wherein the region(s) of ore considered of value includes a portion of waste material and / or impurity.

34. A method as claimed in any one of claims 27 to 33, further including the step of re-iterating an evaluation and / or extraction analysis of the selected material based on the identification of regions.

35. A mine analysed in accordance with the method as claimed in any one of claims 27 to 34.

36. Material extracted from a mine as claimed in claim 35.

37. Apparatus adapted to determine characteristics of a selected portion of material, the apparatus including:

first means to determine the contents of the selected portion of material,
and

means to identify region(s) of material within the selected portion according to at least one of a plurality of characteristic(s).

38. Apparatus including processor means adapted to operate in accordance with a predetermined instruction set,

said apparatus, in conjunction with the instruction set, being adapted to perform the method as claimed in any one of claims 27 to 34.

39. A computer program product including:

computer usable medium having computer readable program code and computer readable system code embodied on said medium for determining slope constraints related to a design configuration for extracting material from a particular location within a data processing system, said computer program product including:

computer readable code within said computer usable medium for performing the method as claimed in any one of claims 27 to 34.

40. A method of analysing a selected volume of material, the material being at least partially comprised of a plurality of blocks, the method including the steps of:

clumping a number of blocks together,

analysing the selected volume of material based on the clumped blocks.

41. A method as claimed in claim 40, wherein a mixed integer optimisation engine is used to analyse the selected volume of material.

42. A method as claimed in claim 41, wherein further constraints are incorporated into the engine.

43. A method as claimed in claim 42, wherein the further constraints are mining, processing, marketing capabilities and/or grade constraints.

44. A method as claimed in any one of claims 40 to 42, wherein analysis of the selected volume is performed relatively globally both in space and time.

45. A mine analysed in accordance with the method as claimed in any one of claims 40 to 44.

46. Material extracted from a mine as claimed in claim 45.

47. A computer program product including:

computer usable medium having computer readable program code and computer readable system code embodied on said medium for determining slope constraints related to a design configuration for extracting material from a particular location within a data processing system, said computer program product including:

computer readable code within said computer usable medium for performing the method as claimed in any one of claims 40 to 43.

48. Apparatus adapted to analyse a selected volume of material, the material being at least partially comprised of a plurality of blocks, the apparatus including:

first means for clumping a number of blocks together,

second means for analysing the selected volume of material based on the clumped blocks.

49. Apparatus including processor means adapted to operate in accordance with a predetermined instruction set,

said apparatus, in conjunction with the instruction set, being adapted to perform the method as claimed in any one of claims 40 to 44.

50. A method of determining a selected group of blocks of a mine pit which are capable of being mined, the method including the step of

selecting a first plurality of blocks, and

determining a relative value and constraints applicable to the selected first plurality of blocks in accordance with:

51

$$\max \sum_i v_i x_i$$

s.t.

$$n_i x_i \leq \sum_{j \in P(i)} x_j$$

$$x_i \in \{0,1\} \quad \forall i$$

where $n_i = |P(i)|$

.....equation 3

51. A method of determining a selected group of blocks of a mine pit which are capable of being mined, the method including the step of
 selecting a first plurality of blocks, and
 determining a relative value and constraints applicable to the selected first plurality of blocks in accordance with:

$$\max \sum_i v_i x_i$$

s.t.

$$n_i x_i \leq \sum_{j \in P(i)} x_j$$

$$0 \leq x_i \leq 1 \quad \forall i$$

where $n_i = |P(i)|$

.....equation 4

52. A method of determining a selected group of blocks of a mine pit which are capable of being mined, the method including the step of
 selecting a first plurality of blocks, and
 determining a relative value and constraints applicable to the selected first plurality of blocks in accordance with:

$$\begin{aligned} & \max \sum_i v_i x_i \\ & s.t. \\ & \quad n_i x_i \leq \sum_{j \in P(i)} x_j \\ & \quad 0 \leq x_i \leq 1 \quad \forall i \\ & \text{where } n_i = |P(i)| \\ & \text{loop over all arcs} \\ & \{ \text{if } i \rightarrow j, \text{ and } x_i > x_j \text{ in solution, then add the constraint } x_i \leq x_j \} \\ & \dots\dots\dots \text{equation 9} \end{aligned}$$

53. A method as claimed in claim 52, further including the step of re-testing for violations.

54. A method as claimed in any one of claims 50 to 53, further including the further step of:

selecting a second plurality of blocks,
determining a relative value and constraints applicable to the selected second plurality of blocks in accordance with any one of equations 3, 4 or 9, and
determining whether the first or second plurality of block have a greater value.

55. A method as claimed in any one of claims 50 to 53, further including the step of repeating the further steps as claimed in claim 5 until substantially no constraints from the problem are found to be violated.

56. A method as claimed in claim 53, wherein a violation greater than or equal to a selected lower bound is added in the first iteration.

57. A method as claimed in claim 56, wherein, on subsequent iteration(s), a constraint with a reduced lower bound is added.

58. A method as claimed in claim 53, wherein a tolerance value is used to determine the number of constraints.

59. A method as claimed in claim 53, wherein the number of constraints added is determined in accordance with:

- a. If the number of constraints does not exceed a memory limit, then add substantially all the constraints, or
- b. If the number of constraints exceeds a memory limit, then add some (only) of the constraints.

60. A method as claimed in claim 53, wherein the constraint added is in accordance with a z co-ordinate.

61. A method as claimed in claim 60, wherein the constraint added is in accordance with the largest z coordinate first.

62. A method of determining a selected group of blocks of a mine pit which are capable of being mined, the method including the step of
selecting a first plurality of blocks, and
determining a relative value and constraints applicable to the selected first plurality of blocks in accordance with:

- a CPLEX method as defined by equation 2, disclosed herein, and
- if the CPLEX method times out, redetermining the relative dimension and / or size of a mine pit using the method as claimed in any one of claims 50 to 61.

63. Apparatus adapted to determining a selected group of blocks of a mine pit which are capable of being mined, the apparatus including:

- processor means adapted to operate in accordance with a predetermined instruction set, said apparatus, in conjunction with said instruction set, being adapted to perform the method as claimed in any one of claims 50 to 62.

64. A computer program product including:

- a computer usable medium having computer readable program code and computer readable system code embodied on said medium for determining the relative dimension and / or size of a mine pit using a data processing system, said computer program product including:

computer readable code within said computer usable medium for determining a selection of blocks of a mine pit which are capable of being mined in accordance with the method as claimed in any one of claims 50 to 62.

65. A method as claimed in any one of claims 1 to 8, 14 to 21, 27 to 34, 40 to 44 and 50 to 62 substantially as herein described with reference to the accompanying drawings.

66. An apparatus as claimed in any one of claims 12 to 15, 23 to 26, 37, 38, 48, 49 and 63, substantially as herein described with reference to the accompanying drawings.

67. A mine design in accordance with the method as claimed in any one of claims 1 to 8, 14 to 21, 27 to 34, 40 to 44 and 50 to 62.

68. Material extracted from a mine in accordance with the design as claimed in any one of claims 12 to 15, 23 to 26, 37, 38, 48, 49 and 63.